department of biological sciences
seminar series

Dr. Matt Schuler
Relyea Lab - RPI

“From pollution to policy: Understanding and mitigating human impacts on freshwater environments”

Monday, March 18, 2019
12:00 Noon
CBIS, Bruggeman Room

refreshments served 11:45
"Solving Inverse Problems on Networks: Graph Cuts, Optimization Landscape, Synchronization"

Abstract: Information retrieval from graphs plays an increasingly important role in data science and machine learning. This talk focuses on two such examples. The first one concerns the graph cuts problem: how to find the optimal k-way graph cuts given an adjacency matrix. We present a convex relaxation of ratio cut and normalized cut, which gives rise to a rigorous theoretical analysis of graph cuts. We derive deterministic bounds of finding the optimal graph cuts via a spectral proximity condition which naturally depends on the intra-cluster and inter-cluster connectivity. Moreover, our theory provides theoretic guarantees for spectral clustering and community detection under stochastic block model.

The second example is about the landscape of a nonconvex cost function arising from group synchronization and matrix completion. This function also appears as the energy function of coupled oscillators on networks. We study how the landscape of this function is related to the underlying network topologies. We prove that the optimization landscape has no spurious local minima if the underlying network is a deterministic dense graph or an Erdos-Renyi random graph. The results find applications in signal processing and dynamical systems on networks.

Shuyang Ling (Courant Institute of Mathematical Sciences, NYU)

Monday, March 18, 2019

4-5pm

Amos Eaton 214

Host: Yangyang Xu

Refreshments served 3:30-4pm Amos Eaton 4th Floor Lounge
Development of clean and sustainable renewable energy is able to address the challenges associated with the rapidly increasing global energy demand and possible climate changes caused by carbon dioxide emission. However, people argue that we can’t effectively utilize renewable energy until appropriate energy conversion and storage technologies are developed. Among available energy conversion technologies, proton exchange membrane fuel cells (PEMFCs), which directly convert chemical energy of fuels to electricity, have been widely considered a clean energy technology due to their high efficiency, high power density, environmental friendliness, and high reliability. However, several challenges must be overcome before large-scale commercialization of PEMFCs can be realized, such as high costs, insufficient durability, and hydrogen fuel related technologies. The high cost is due to the use of Pt catalysts for the sluggish oxygen reduction reaction (ORR) in PEMFC cathodes. It has been reported that platinum group metal (PGM) catalysts represent about 45% of the entire cost in the state-of-the-art PEMFCs. To address the cost issues, Pt catalysts must be replaced by PGM-free catalysts derived from earth-abundant elements. Therefore, it is scientifically and technically important to develop high-performance PGM-free cathode catalysts. Compared to other studied PGM-free formulations, carbon-based catalysts often possess many advantages including their excellent electrical conductivity, high surface areas, low-cost, and easiness of functionality. However, proper doping with heteroatoms (e.g., N, S, P) and transition metals (e.g., Fe, Co, or Mn) to modify the electronic and geometric structures of carbon is the key to enhancing catalytic performance. Herein, we introduce a new class of atomically dispersed and nitrogen coordinated metal-based carbon catalyst through controlled chemical doping of metals ions (Fe, Co, or Mn) into zinc-rich zeolitic imidazolate framework (ZIF), a type of metal-organic framework (MOF). The novel synthetic chemistry enables accurate controls of metal doping levels, particle sizes, and nanostructures of catalysts, which allows us to establish synthesis-structure-activity correlations. The best performing catalyst with optimal morphology and structure has achieved a new performance milestone for the ORR in challenging acidic media comparable with state-of-the-art Pt/C. The high-performance atomic metal-rich catalysts hold great promise to replace Pt for future fuel cells as well as for other sustainable electrochemical energy storage and conversion applications such as CO₂ reduction and NH₃ electrosynthesis.
Abstract

Genome mapping in nanochannels is an emerging method for obtaining large-scale genomic information at the single molecule level. In this method, large pieces of contiguous genomic DNA, hundreds of kilobase pairs in length, are labeled with a sequence-specific fluorescent probe while the backbone is labeled with a second color. Upon injection into a nanochannel, the labeled molecule stretches due to confinement and the locations of the probes are read by fluorescence microscopy. I will present our experimental and theoretical progress towards understanding the thermodynamics and hydrodynamics of DNA when it is confined in a nanochannel, as well as how this knowledge can be used to improve genome mapping technology.

Biography

Kevin Dorfman is the L.E. Scriven Chair of Chemical Engineering and Materials Science at the University of Minnesota. He received his PhD in Chemical Engineering in 2002, working with Howard Brenner, and was a postdoctoral fellow with Jean-Louis Viovy at the Institut Curie in Paris, France from 2002-2005. He joined the University of Minnesota in 2006. His research, which involves both computational and experimental components, focuses on polymer physics, transport in microfluidic and nanofluidic devices, and applications of these topics to problems in biotechnology. His work has been recognized by a number of awards, including a Packard Fellowship and the Colburn Award of the AIChE.

Refreshments: 9:00 a.m., Coonley Lounge
“Multiscale Energy Transfer within Turbulence”

James M. Chen, Ph.D.
Department of Mechanical and Aerospace Engineering
University at Buffalo

Wednesday, March 20, 2019
10:30 AM - 11:30 AM
DCC 318

Abstract: The coupling between the intrinsic angular momentum and the hydrodynamic linear momentum has been known to be prominent in fluid flows involving physics across multiple length and time scales, e.g., turbulence, nonequilibrium flows and flows at micro-nano-scale. Since the classical Navier-Stokes (NS) equations and Boltzmann’s kinetic theory are derived on the basis of monatomic gases or volumeless points, efforts to derive constitutive equations involving intrinsic rotation for fluids have been found since the 1960s. One of the proposed efforts is the morphing continuum theory (MCT), reformulated by the speaker through kinetic theory and the Boltzmann-Curtiss formulations. The kinetic nature of MCT will be briefly introduced in this talk. The multiscale nature of MCT allows one to observe the separate routes of energy transfer during the cascade. The direct relations between MCT and NS will also be discussed. Several cases will be presented in this seminar. The first one is the homogeneous isotropic turbulence, which focuses on the energy routes and their physical meanings. MCT predicts a similar energy decay rate as that in the NS-based DNS, and the detailed energy transfer through different routes are presented. The second case is a supersonic turbulence over a compression ramp, where the results are compared with the experimental measurements and the energy analysis can be used to establish turbulence models. The last case is a transonic turbulence over an axisymmetric hill, which compares the computational cost of MCT-based DNS with that of the NS-based DNS. The simulation shows that MCT only requires a mesh number an order less than that used in a NS-based study while providing a better prediction on the pressure profile.

Bio: Dr. James M. Chen is an Assistant Professor in the Department of Mechanical and Aerospace Engineering at University at Buffalo (UB). He earned his B.S. at National Chung-Hsing University (2000), M.S. at National Taiwan University (2005) and Ph.D. in mechanical and aerospace engineering and applied mathematics (minor) at The George Washington University (2011). Prior to joining UB, He was an Assistant Professor and the endowed Steve Hsu Keystone Scholar at Kansas State University (2015-2018) and an Assistant Professor at the Pennsylvania State University system. He has published more than 30 peer-reviewed journal articles in multiscale computational mechanics, fracture mechanics, theoretical & computational fluid dynamics and atomistic simulation for thermo-electro-mechanical coupling. He received the Young Investigator Award from Air Force Office of Scientific Research in 2017 and the Outstanding Young Engineer Award from the Wichita Council of Engineering Societies in 2018. His research at MCPL has been supported by AFOSR, NSF and NASA and recognized by numerous media outlets, including NSF, EurekAlert, Science Daily and a radio show in Austria. His current interests are on continuum mechanics, compressible turbulence, supersonic/hypersonic flows, atomistic electrodynamics, fracture mechanics, triboelectricity and high-level programming.
“Geotechnical Site Characterization by Seismic Piezocone Testing – the versatile and complete beyond (update keynotes from CPT’14, Las Vegas; Nonveiller Lecture, Zagreb 2016; Jennings Lecture, South Africa”

Wednesday, March 20, 2019

Eaton 214 - 1:00 – 2:00pm

Dr. Paul W. Mayne, P.E.

Professor – Geosystems Engineering
Georgia Institute of Technology

ABSTRACT:
Towards geotechnical site characterization of soils, seismic piezocone penetration testing (SCPTu) offers up sounding: cone tip resistance (qt), sleeve friction (fs), porewater pressure (u2), time rate dissipation (t50), and downhole and the data are available immediately upon completion of the sounding, typically taking only about 3 hours for a 30-m economical means for obtaining stratification of the ground. Calibration and documentation of selected geoparameters friction angle, preconsolidation stress, undrained shear strength, Ko stress state, small-strain stiffness, soil modulus, and can be derived for clays, silts, and sands. Moreover, direct CPT methodologies have been developed for application to evaluation. Several case studies are presented to show the utilization of SCPTu in geotechnical practice.

BIO:
Paul W. Mayne. P.E., PhD, is a professor of Civil & Environmental Engineering at the Georgia Institute of Technology. With 42 years in geotechnical engineering, Paul is an expert in geotechnical site characterization, particularly the cone penetrometer, piezocone, dilatometer, and seismic tests with applications to foundation systems and ground modification. He has published 330 technical papers and participated in 120 short courses. Of recent, Paul authored the 2007 Synthesis 368 on Cone Penetration Testing (www.trb.org), co-authored the SOA-1: Geomaterial Behavior & Testing at the 17th ICSMGE in Egypt in 2009. Dr. Mayne is an active member of ASCE, TRB, DFI, ADSC, CGS, USUCGER, and ISSMGE.

Refreshments will be served
Photonic Crystal Light Trapping: The Key to Breaking Photovoltaic Efficiency Barriers

The thermodynamic power conversion efficiency limit for silicon solar cells is close to 33%, while commercially available cells have efficiencies in the 17-20% range. The world record for silicon solar cells has inched upward from 25% to 26.7%, in the past twenty years, using cell thicknesses ranging from 450 microns to 165 microns. Photonic crystal architectures enable broadband light absorption beyond the longstanding Lambertian limit and allow silicon to absorb sunlight nearly as well as a direct-bandgap semiconductor. When combined with state-of-the-art electronics, a technological paradigm shift appears imminent. In this lecture, I describe how wave-interference-based solar light-trapping in realistic photonic crystals can break longstanding barriers, enabling flexible, thin-film, silicon to achieve an unprecedented, single-junction, power conversion of 31% [1, 2].


2. “Beyond 30% conversion efficiency in silicon solar cells” S. Bhattacharya and Sajeev John (to be published)